REMARKS

Reconsideration of this application, as amended, is respectfully requested.

THE ABSTRACT AND SPECIFICATION

The specification has been amended to correct some minor grammatical errors of which the undersigned has become aware, and the abstract has been amended to put same in better U.S. form.

Submitted herewith are marked copies of the changed pages to show that no new matter has been added, and full replacement paragraphs are set forth hereinabove.

It is respectfully requested that the amendments to the abstract and specification be approved and entered.

THE CLAIMS

Claim 1 has been amended to recite the feature of the present invention whereby a pair of wafer holders are adapted to arrange a pair of wafers in such a manner that the wafers are disposed in mutually opposing positions with their surface areas which are subject to epitaxial growth adjacent to and parallel with each other so that a reaction chamber is formed between the wafers, as supported by the disclosure in paragraphs 0014, 0028, 0030, 0037, 0038, and 0040 and by the disclosure in Figs. 1 and 2.

In addition, claims 2-4 have been amended to better accord with the recitation in amended claim 1, and new claim 5 has been

added to recite that the pair of wafer holders are adapted for vertical arrangement of the pair of semiconductor wafers so that the wafers are placed upright with each wafer surface vertically arranged in the reaction chamber, as supported by the disclosure in paragraphs 0023, 0030 and by the disclosure in Figs. 1 and 2.

Still further, some minor amendments have been made to the claims to make minor grammatical improvements and/or to correct minor antecedent basis problems.

Submitted herewith are copies of the original claims marked to show the changes made, and clean versions of the amended claims are set forth hereinabove.

No new matter has been added, and it is respectfully requested that the amendments to the claims be approved and entered.

THE PRIOR ART REJECTION

Claims 1 and 2 were rejected under 35 USC 103 as being obvious in view of the combination of JP 06-267855 ("Suzuki") and USP 5,094,885 ("Selbrede"); claim 3 was rejected under 35 USC 103 as being obvious in view of the combination of Suzuki, Selbrade and USP 5,458,322 ("Kulkaski et al"); and claim 4 was rejected under 35 USC 103 as being obvious in view of the combination of Suzuki, Selbrede and EP 840 358 ("Balance et al"). These rejections, however, are respectfully traversed with respect to the claims as amended hereinabove.

According to the present invention as recited in amended claim 1, an epitaxial growth furnace is provided which enables simultaneous formation of epitaxial layers on a pair of semiconductor wafers of large-diameter in a manner such that the effective area of the wafer surface adapted for epitaxial layer formation can be increased and in a manner such that there is no danger of causing contamination due to deposition of a reaction product on the periphery of the wafer holder flange. More specifically, according to the present invention as recited in amended claim 1, a pair of wafer holders are adapted to arrange a pair of wafers in such a manner that the wafers are disposed in mutually opposing positions with their surface areas which are subject to epitaxial growth adjacent to and parallel with each other so that a reaction chamber is formed between the wafers.

Suzuki discloses an apparatus for manufacturing vapor growth film in which a susceptor 12 is adapted to arrange a substrate 11 in such a manner that the surface to be processed for forming a vapor growth film 14 faces downward. In the apparatus of Suzuki, a disc type protective retainer 13, of a shape substantially corresponding with the shape of the substrate retaining recess 12A of the susceptor 12, is inserted into the recess 12A to stably retain the substrate 11 on the susceptor 12. This means that in the apparatus of Suzuki the back surface of the substrate is completely shut from exposure to heat radiation from the back side of the susceptor.

Accordingly, in the apparatus of Suzuki, it is impossible to achieve a structure whereby a pair of susceptors are adapted to dispose a pair of substrates in mutually opposing positions so that a reaction chamber is formed between the substrates in the manner of the claimed present invention, since in Suzuki the necessary heating of the substrate with heat radiation from the back side is inhibited by the existence of the protective retainer disc 13.

It is respectfully submitted, moreover, that Selbrade, Kulkaski et al and Ballance et al also fail to disclose, teach or suggest the feature of the of the present invention as recited in amended claim 1 whereby a pair of wafer supports are adapted to dispose a pair of wafers in mutually opposing positions so that a reaction chamber is formed between the wafers.

Accordingly, it is respectfully submitted that amended claim 1 as well as each of claims 2-5 depending therefrom, all patentably distinguish over the cited references, taken singly or in any combination, under 35 USC 103.

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In view of the foregoing, entry of this Amendment, allowance of the claims and the passing of this application to issue are respectfully solicited.

If the Examiner has any comments, questions, objections or recommendations, the Examiner is invited to telephone the undersigned at the telephone number given below for prompt action.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

Claims 1-4 have been amended as follows:

1. (Amended) An epitaxial growth furnace [for effecting the] comprising:

a sealed chamber; and

a pair of wafer holders for holding a pair of semiconductor wafers within said chamber;

wherein formation of an epitaxial layer on [the] a surface of [a semiconductor wafer] each of said wafers is effected by supplying under a high temperature condition a source gas to a surface area of [the semiconductor wafer,] each of said wafers;

wherein said wafer holders are adapted to arrange said pair of wafers in such a manner that the wafers are disposed in mutually opposing positions with each said surface area adjacent to and parallel with each other so that a reaction chamber is formed between said wafers;

wherein said surface [area being] areas are subject to epitaxial growth within [a sealed chamber of the furnace, said wafer being supported by a wafer holder within said chamber,] said reaction chamber; and

wherein each of said wafer [holder] holders comprises:

an opening for exposing one of said surface [area] areas of the [wafer] wafers to said reaction chamber;

an opening flange adapted for engagement with a chamfered tapered face of a whole peripheral edge of one of said [wafer] wafers on [the] a side of said surface area thereof; and

a plurality of [jaw means adapted] jaws for detachably engaging with an outer periphery of one of the [wafer] wafers on a back surface side of said surface area thereof.

2. (Amended) An epitaxial growth furnace according to claim 1, wherein the opening flange of each of said wafer [holder] holders is adapted to contact only with the chamfered tapered face of the whole peripheral edge of one of said [wafer] wafers on the side of said surface area thereof which is subject to epitaxial growth.

3. (Amended) An epitaxial growth furnace according to claim 1, [wherein each of said jaw means of said wafer holder] further [comprises spring means] comprising a plurality of springs for respectively thrusting [each said jaw means] said jaws toward a center of said opening, and detachable actuating means for locking each of said [jaw means] jaws in a released position against [the] respective thrust [forcse] forces from said [spring means] springs.

4. (Amended) An epitaxial growth furnace according to claim 2, wherein each <u>of</u> said [jaw means] <u>jaws</u> includes an inclined face corresponding to [a] <u>the</u> chamfered tapered face of the peripheral edge of <u>one of</u> the [wafer] <u>wafers</u> on said back surface side thereof.

Version with markings to show changes made

peripheral shape, and this opening flange comes into contact with the whole tapered face on the wafer surface side so that the holder opening is completely closed by the wafer and therefore substantially no space is left between the holder and the peripheral edge of the wafer.

[0013] Thus, where a source gas is supplied only to the wafer surface side, the source gas is prevented from flowing around from the surface side to the back side of the wafer through between the holder and the wafer peripheral edge. As a result, there is no possibility of the source gas going round to the wafer back surface side being brought into contact with the heating mechanism arranged in the vicinity of the wafer back surface thereby causing the deposition of a reaction product and making difficult the maintenance of uniform heating conditions, and also there is no danger of deteriorating the quality of the wafer.

[0014] As regards a desired construction for source gas supply such that a source gas is supplied only to the surface side of a wafer and it is prevented from flowing around from the holder outer peripheral edge to the wafer back surface side, as for example, a construction is conceivable in which a pair of semiconductor wafers are arranged adjacent to each other so that their surfaces oppose each other parallely within the chamber and a source gas is circulated as a laminar flow only through between the wafers by means of upper and lower supply and exhaust systems. Further, it is possible to construct so that the whole peripheries of two wafers are covered to form an independent reaction space separated from the surroundings and a source gas is exclusively circulated within the reaction space.

[0015] In accordance with a preferred aspect of the present invention, the opening flange of the wafer holder comes into contact only with the whole chamfered tapered face of the border of a semiconductor wafer on the side of its surface which is subject to epitaxial growth. The opening flange can also supports the wafer through the contact with the tapered face without allowing the slipping out of the wafer to its surface side; in this case, the opening flange does

is applied to the semiconductor wafer with the result that under the high temperature environment during epitaxial growth, there is the danger of causing slip deformation of the crystal thus causing irregularities in the wafer surface, that is, the induction of so-called slip defect.

[0019] Also, as regards the arrangement of the jaws, it is most desirable that their positions and number are selected in such a manner that each of the jaws applies a uniform pressing force to a part of the semiconductor wafer having a high mechanical strength. For instance, the semiconductor wafer is generally a silicon wafer substrate cut at the crystal plane (100), and it is well known that in this case the mechanical strength is highest at the positions along the crystal orientation <100> of the surface.

[0020] Thus, if the positions of the jaws of the wafer holder relative to the semiconductor wafer are selected so as to correspond to such four parts along the holder periphery that the pressing directions of the respective jaws coincide with the crystal orientation <100> of the semiconductor wafer, the semiconductor wafer is pressed and held among the jaws at least at those parts of the wafer where the mechanical strength is highest physically and therefore the semiconductor wafer can be held more stably. This is especially advantageous in the case of large-diameter semiconductor wafers which are large in weight.

[0021] In fact, while the use of two jaws is sufficient, ~~suffice~~ if it is desired to simply hold the semiconductor wafer in place, such two-point support causes the wafer to tend to bend under its own weight and this trend is particularly manifest in the case of wafers of large diameters. Therefore, the wafer holder of the present invention is constructed so as to include at least three jaws. Considering from the design and production point of view, it is convenient to use a construction including three jaws or the previously mentioned construction having four jaws. Of course, it is possible to include five or more jaws and in any case the jaws are arranged at equal angular intervals along the holder periphery.

[0022] It is to be noted that where a semiconductor wafer is formed with a

chamfered tapered face on the back side periphery in addition to that on the surface side, the contacting portion of each jaw may be formed into a shape having an inclined face corresponding to the tapered faces of the border on the both sides of the wafer thereby making the holding condition of the semiconductor wafer more stable.

[0023] Further, in accordance with the wafer holder of the present invention constructed so as to hold the peripheral edge of a semiconductor wafer from the both sides as mentioned previously, the semiconductor wafer can be vertically arranged (placed upright with the wafer surface along the vertical direction) thereby preventing the occurrence of any warp due to its own weight which can cause a crystal defect in the wafer, and also it can be used with upright type systems which are capable of simultaneous epitaxial growth processing of two or more semiconductor wafers and considered to be suitable for large-diameter wafers.

Brief Description of Drawings

[0024] Fig. 1 is a schematic front view showing, as ~~looked~~ seen from the wafer back surface side, the interior of the chamber of an epitaxial growth furnace according to an embodiment of the present invention.

[0025] Fig. 2 is a longitudinal sectional view showing the chamber interior of Fig. 1 as ~~looked~~ seen from the lateral side.

[0026] Figs. 3a and 3b show the construction of a wafer holder used in the epitaxial growth furnace of Fig. 1, in which Fig. 3a is its plan view as ~~looked~~ seen from the back side and Fig. 3b is its cross-sectional view.

[0027] Figs. 4a to 4c show the construction of the jaw actuating means in the wafer holder of Figs. 3a and 3b, in which Fig. 4a is ~~its~~ a partial enlarged plan view as ~~looked~~ seen from the holder back side, Fig. 4b ~~its~~ is a partial cross-sectional view, and Fig. 4c ~~its~~ is an enlarged cross-sectional view of the jaw and the associated parts.

Best Mode for Carrying Out the Invention

[0028] An epitaxial growth furnace according to an embodiment of the present invention has a construction which employs wafer holders each including a plurality of jaws operated by a plurality of spring-type actuating means so as to permit simultaneous formation of epitaxial layers on a pair of semiconductor wafers.

[0029] In the epitaxial growth furnace of the present embodiment, a pair of substantially cylindrical drum-type susceptors 2 are rotatably supported within a chamber 1 as shown in the schematic front view of Fig. 1 showing the interior of the chamber as ~~looked~~ seen from the back surface side of a semiconductor wafer and the central sectional view of Fig. 2 showing the chamber as ~~looked~~ seen from the lateral side.

[0030] Disposed in the respective opposing end-side openings of the cylindrical drums of the susceptors 2 are wafers 10 which are held upright in the vertical direction through wafer holders 11 in such a manner that their respective surfaces subject to epitaxial growth are exposed in mutually opposing positions. The peripheral edge of each susceptor opening corresponds to the outer peripheral shape of the wafer holder 11 and the peripheral edge of the wafer holder 11 is detachably held by a plurality of locking means R so as to close the susceptor opening.

[0031] On the other hand, a rotating fin 3 including a plurality of vanes is attached onto the outer peripheral surface of each susceptor 2. The fin 3 is rotated by the supply of gas blown to the vanes from a rotating gas supply pipe 4 so that the cylindrical drum-type susceptor 2 is rotated on a horizontal axis by the rotation of the fin 3 and this rotation causes the semiconductor wafer 10 held in a vertical plane to rotate about the horizontal axis along with the wafer holder 11.

[0032] Figs. 3a and 3b show the construction of the wafer holder 11 used in the epitaxial growth furnace of the present embodiment, in which Fig. 3a is a plan view ~~looked~~ as seen from the back side and Fig. 3b is a cross-sectional view. Figs.

4a to 4c show the spring-type actuating means of the wafer holder 11, with Fig. 4a showing a partial enlarged plan view ~~looked~~ as seen from the back side, Fig. 4b showing a partial sectional view of the actuating means, and Fig. 4c showing a schematic view useful for explaining the operation of the jaw.

[**0033**] As shown in Figs. 3a, 3b and 4a to 4c, the wafer holder 11 is formed into a ring shape having in its central portion an opening for exposing the surface Sb of the wafer 10 which is subject to epitaxial growth. An opening flange 12 is shaped so that it engages with only the chamfered tapered face of the peripheral edge on the surface side Sb of the wafer 10 so as to contact with its whole periphery and thereby to prevent the wafer 10 from escaping to the surface side. Thus, when the wafer 10 is loaded on the holder 11 with the peripheral edge of the surface side Sb in contact with the opening flange 12, the opening of the holder 11 is closed tightly by the wafer 10.

[**0034**] Also, the wafer-back side Sa of the holder 11 (hereinafter referred to as a holder back side) is provided with four jaw actuating means 13 which are arranged at equal angular intervals. The actuating means 13 are each constructed so that the associated jaw 14 is preliminarily energized towards the center of the holder opening by its spring 16 and the jaw 14 is retracted against the preliminary energization by the spring 16 and locked in this condition thereby attaining a released position. In its free condition, each jaw 14 has its forward end 15 projected inwardly of the opening flange 12.

[**0035**] Thus, when the jaws 14 in their released positions are unlocked after the wafer 10 has been loaded on the holder 11 by bringing its surface side peripheral edge into engagement with the opening flange 12, the forward ends 15 of the jaws 14 are again moved toward the opening center in response to the energization by the springs 16 and are pressed toward the center from four wafer circumferential directions to hold the peripheral edge on the back side of the wafer 10 thereby holding the wafer 10 in place. Note that with the present embodiment, it is assumed that when loading the wafer 10 on the holder 11, its

ABSTRACT

~~Disclosed is an~~ An epitaxial growth furnace is provided for effecting the formation of an epitaxial layer on the surface of a semiconductor wafer by CVD in a reaction chamber of the furnace. The furnace comprises a wafer holder having an opening for exposing ~~an~~ a surface area of the wafer which ~~surface area~~ is subject to epitaxial growth, an opening flange adapted for engagement with a chamfered tapered face of a whole peripheral edge of the wafer on the side of said surface area thereof, and a plurality of ~~jaw means adapted~~ jaws for detachably engaging with an outer periphery of the wafer on a back surface side of said surface area.